METHOD OF POLISHING SEMICONDUCTOR COPPER INTERCONNECT INTEGRATED WITH EXTREMELY LOW DIELECTRIC CONSTANT MATERIAL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to technology of polishing wafer, and more particularly, to a method of polishing copper & Tantalum Nitride (Ta/TaN) interconnect integrated with an extremely low dielectric constant material, which works on the surface of wafer by means of ultrasonic waves.

2. Description of the Related Art

A conventional chemical mechanical polish method (CMP) can work on wafer with greater force. As to the wafer integrated with low dielectric constant material, which is low in intensity, durability, hardness, and stability, it needs extremely low down and shear force to polish the wafer; otherwise, lead frame or dielectric layer or interface of the film on wafer will be spoiled. If the aforementioned extremely little force is made by decreasing a down force by a precise control technique, it will be difficult to manufacture such a particular machine, which performs the precise control technique, and will cost a lot of money. In addition, a barrier layer positioned on the wafer is made of the chemically inert Ta/TaN, such that polishing the wafer with extremely little force is hardly possible. Hence, the conventional method of polishing wafer with great force will hardly meet the future requirement of polishing copper & Ta/TaN, which are integrated with extreme-low dielectric constant material.

Furthermore, though another conventional method of polishing wafer without forces by chemical or electrochemical treatment, relatively to the mechanical pressure

used by a conventional method of polishing wafer, applies no force on the surface of wafer, it merely successfully works on a copper layer but ineffectively on the barrier layer.

SUMMARY OF THE INVENTION

The primary objective of the present invention is to provide a method of polishing metal and barrier layer interconnect integrated with an extremely low dielectric constant material, which improves the drawbacks of the mechanical great force and the electrochemical non-force of the conventional polishing methods and is adapted to work on semiconductor copper interconnect integrated with the extremely low dielectric constant material.

The foregoing objective of the present invention is attained by the method of polishing metal and barrier layer interconnect integrated with an extremely low dielectric constant material, which includes steps of (A) preparing a wafer composed of a copper layer and the extremely low dielectric constant material, (B) treating the copper layer chemically to produce a hard and brittle surface residual formed on the surface of the copper layer, (C) keeping polishing the surface residual by ultrasonic waves, and (D) polishing a barrier layer of the wafer by the ultrasonic waves, thereby polishing the wafer successful.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of wafer on which the present invention constructed according to a first preferred embodiment is working;

FIGS. 2A, 2B, and 2C show the variations of the surface of the wafer during the polishing process constructed according to the first preferred embodiment of the present invention;

FIG. 3 is a schematic view of the wafer on which the present invention

constructed according to a second preferred embodiment is working;

FIG. 4 is a perspective view of the wafer on which the present invention constructed according to a second preferred embodiment is working by means of ultrasonic waves; and

FIG. 5 is a schematic view of the wafer on which the present invention constructed according to a third preferred embodiment is working.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. 1 and 2, a method of polishing metal and barrier layer interconnect integrated with an extremely low dielectric constant material, which is constructed according to a first preferred embodiment of the present invention, includes steps as follows.

A. Prepare a wafer 10 composed of a copper layer 11 and the extremely low dielectric constant material 21; wherein, the copper layer 11 is positioned over the low dielectric constant material 21, and a barrier layer 31 embodied as Tantalun Nitride which is a chemically inert, hard, and brittle ceramic material is positioned between the copper layer 11 and the low dielectric constant material 21.

B. Treat the copper layer 11 chemically to produce a hard and brittle surface residue layer 12 embodied as a cuprous compound layer on the surface of the copper layer 11. For example, the cuprous compound layer can be cuprous oxide, which is preferably hard and brittle to be evenly polished by ultrasonic waves.

C. Apply the ultrasonic waves to a pad 51 to enable the pad 51 to move and to further enable abrasive of abrasive slurry to polish the surface residue layer 12, as shown in FIG. 2A, thereby removing the surface residue layer 12 uniformly, as shown in FIG. 2B.

D. Apply the ultrasonic waves to the tool with the pad 51 to enable the pad 51

to move and to further enable the abrasive of the abrasive slurry to polish the barrier layer 31, thereby causing the polished barrier layer 31 successfully, as shown in FIG. 2C.

In the present embodiment, the ultrasonic waves 90 applied to the pad 51 which contacts the surface of the wafer 10 can be transversal or longitudinal waves; the transversal waves enable transversal traveling waves or standing waves parallel to the surface of the wafer 10 to drive the pad 51 to proceed elliptical movement, and meanwhile, a rough surface of the pad 51 drives the abrasive of the abrasive slurry to polish the wafer 10; the longitudinal waves enable longitudinal traveling waves or standing waves perpendicular to or crossed with the surface of the wafer 10 at any angle to drive the abrasive of the abrasive slurry to reciprocate and impact on the wafer 10, and meanwhile, the surface residue layer 12 of the wafer 10 is of brittle fracturing during polishing process; In addition, the transversal waves can enable longitudinal traveling waves or standing waves parallel to the surface of the wafer 10 to drive the pad 51 to reciprocate, and meanwhile, the rough surface of the pad 51 drives the abrasive of the abrasive slurry to polish the wafer 10.

Referring to FIGS. 3 and 4, the method of polishing semiconductor copper interconnect integrated with the extremely low dielectric constant material, which is constructed according to a second preferred embodiment of the present invention, is different from the aforementioned embodiment only in steps C and D as follows.

C. Apply extremely great cavitation damage of cavitation generated by means of scanning of the ultrasonic waves 90 clustered by array-type structure to the very surface and very micro area of the surface residue layer 12' to cause the brittle fracturing of the surface residue layer 12', thereby polishing the wafer 10 successfully.

D. Apply the extremely great cavitation damage of the cavitation generated by

means of scanning of the ultrasonic waves 90 clustered by array-type structure to the very surface and very micro area of the barrier layer 31' to cause the brittle fracturing of the barrier layer 12', thereby polishing the wafer 10 successfully.

In this embodiment, except the pad, only the cavitation generated by the ultrasonic waves is applied to polish the surface of the wafer.

Referring to FIG.5, the method of polishing semiconductor copper interconnect integrated with the extremely low dielectric constant material, which is constructed according to a third preferred embodiment of the present invention, is different from the aforementioned embodiments only in steps C and D in which the ultrasonic waves 90 are applied to a pad 51" to enable the pad 51" to drive the abrasive slurry 52" to flow on the surface of the wafer 10", thereby generating and applying shearing force to polish the surface of the wafer 10". During the aforementioned process, the pad 51" never touches the surface of the wafer 10". The ultrasonic waves generate the hydrodynamic pressure for reducing the threshold pressure of the polishing process by eliminating the hydroplaning effect. Such kind of the ultrasonic polishing process is also worked as assistance to enhance the chemical treatment to render uniform effect.

In light of above three preferred embodiments of the present invention, the polishing process of the copper layer can be done not only by polishing the brittle and hard surface compound of the copper layer by the ultrasonic waves, but also polishing the surface residue layer of the soft material on the conventional copper layer by extremely little force generated by various applications of the ultrasonic waves, which causes uniform polishing effect.

Please be noted that the brittle surface residue layer 12 generated by the chemical treatment is not only limited to a cuprous compound layer but can be anything brittle generated by other chemical treatment.

In conclusion, the present invention utilizes the ultrasonic waves 90 to proceed to micro polishing not only on the surface of the wafer 10 to avoid great mechanical force, but also effectively on the copper layer 11 and the barrier layer 31. In addition, the pulse force is generated during polishing process, such that the damage owing to the extremely low dielectric material could be avoided. Accordingly, the present invention effectively improves the drawbacks of the conventional CMP and the conventional chemical polish.